Global CFC-11 and CFC-12 measurements from MIPAS

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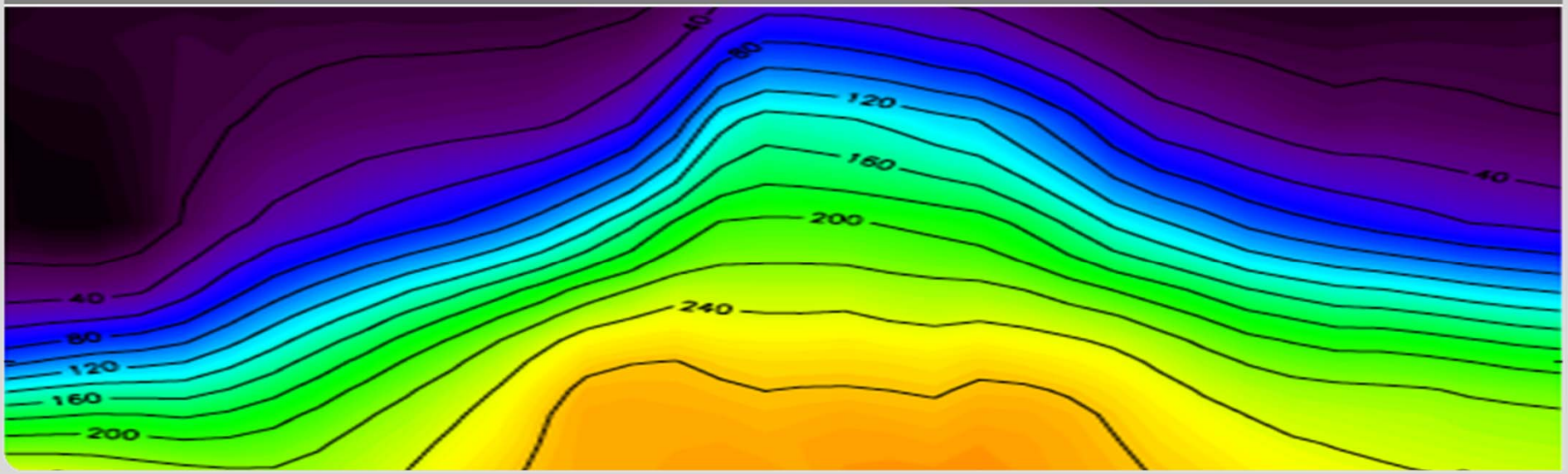
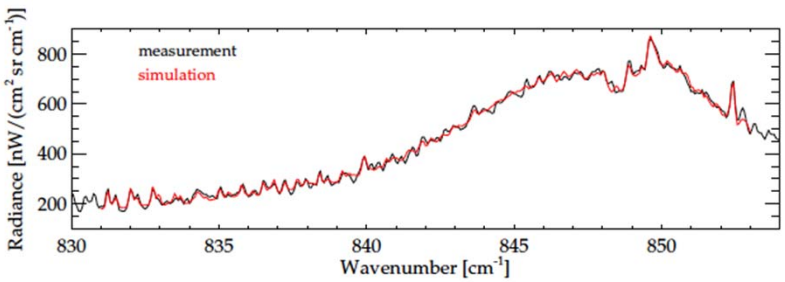
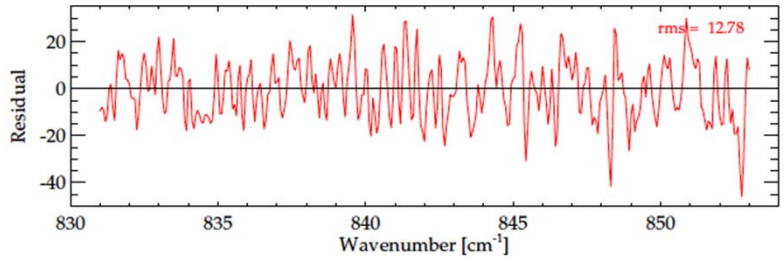


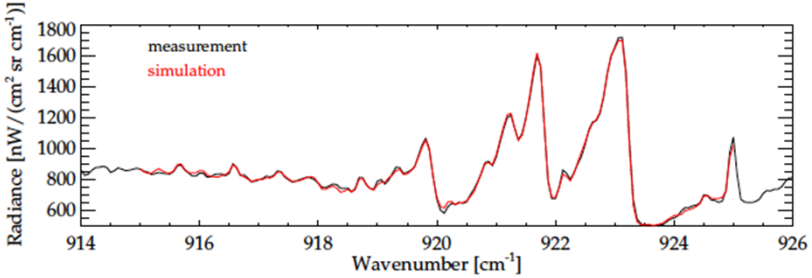
Motivation for the analysis of CFCs

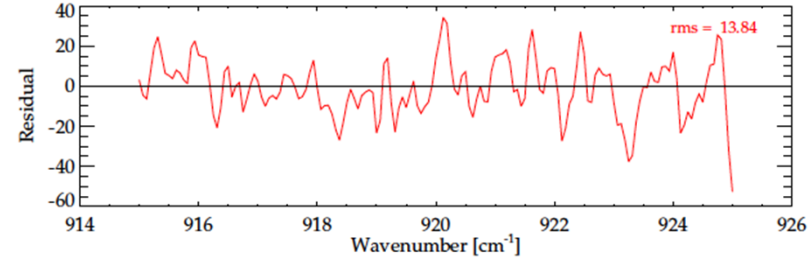
- The expected decrease of the ODS according to the Montreal protocol needs to be monitored
- CFCs are tracers to be used for analysing transport and mixing processes in the stratosphere
- The lifetime of many ODS is under debate recently, because modeled mean age and tracer distributions are in disagreement (Ko et al., 2012)

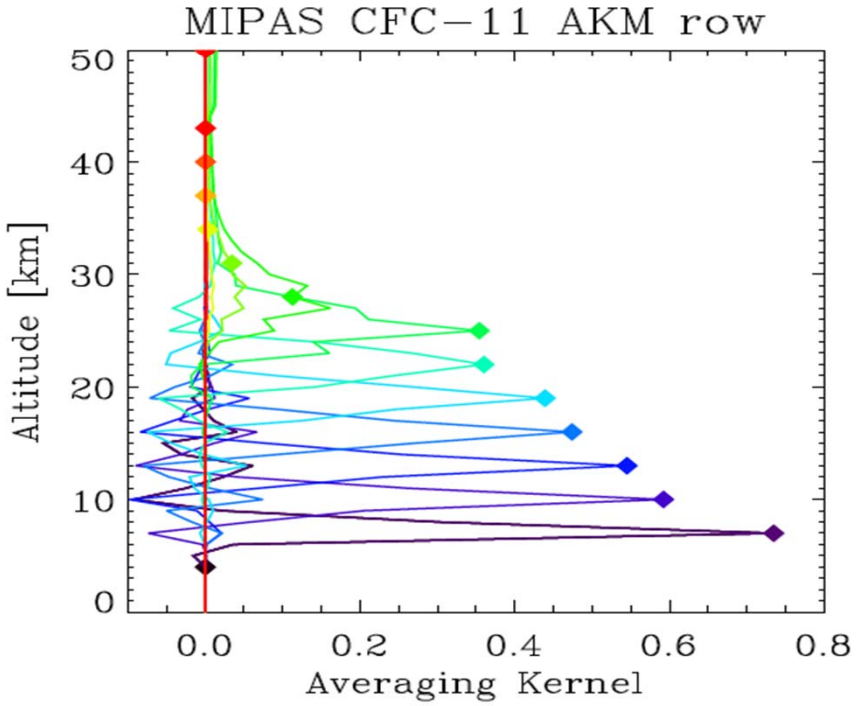
Spectroscopic signatures and retrieval

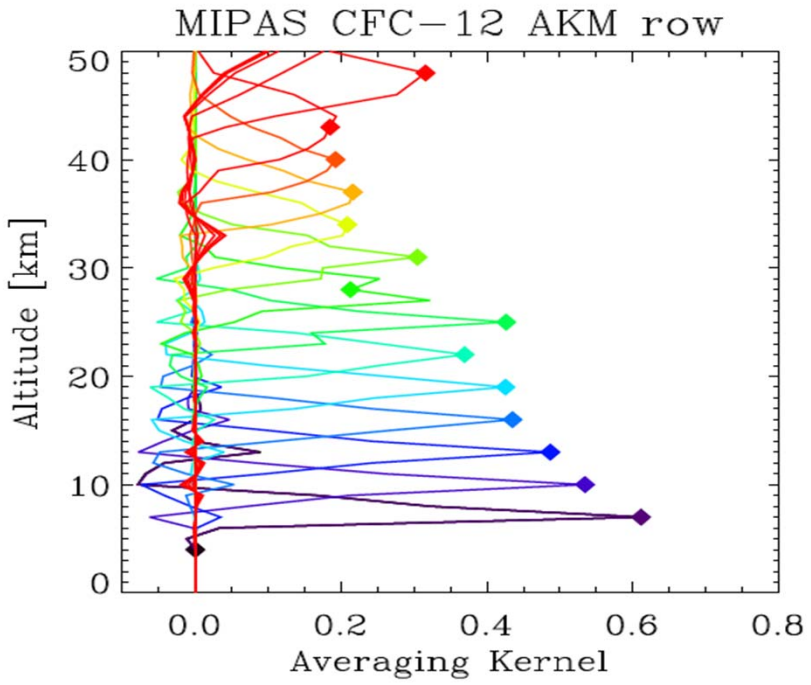




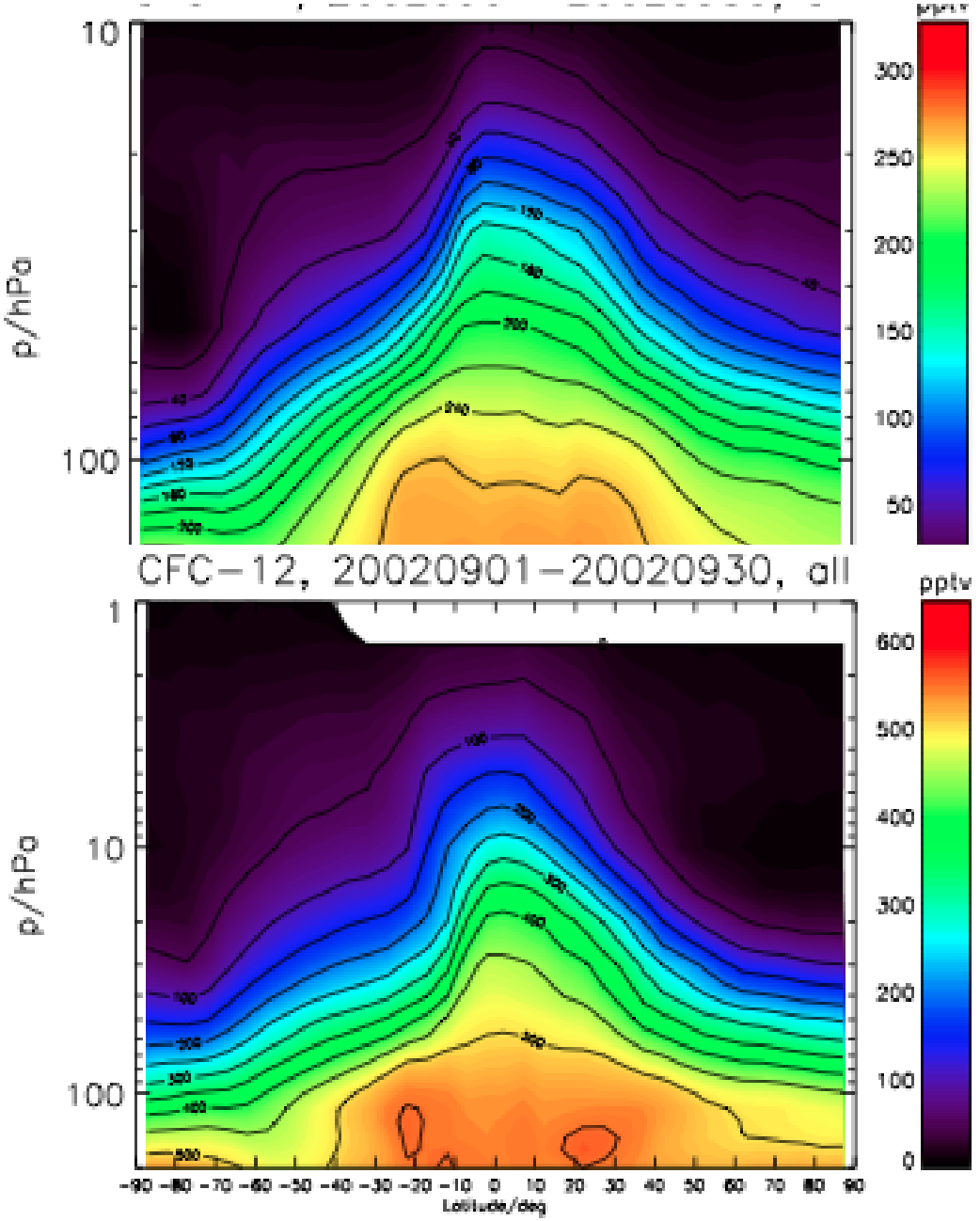








Global CFC-11 and CFC-12 distributions derived from MIPAS – zonal means



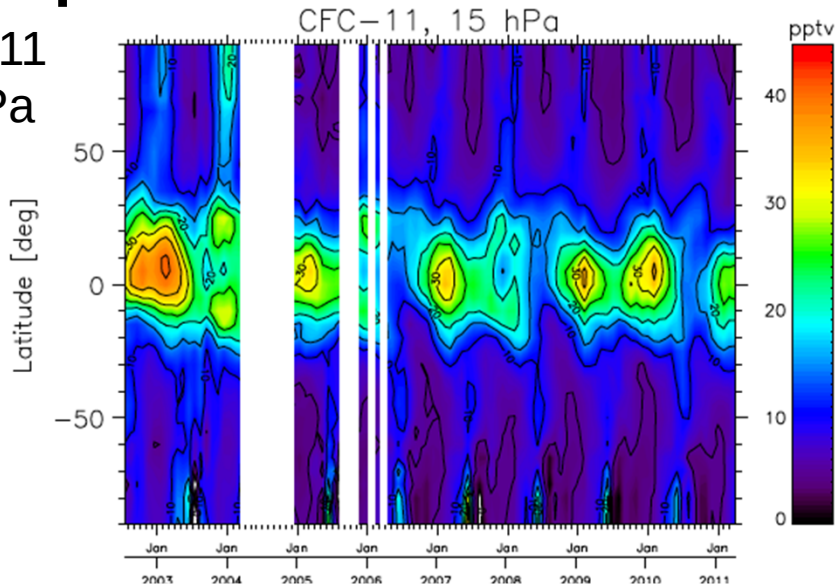
CFC-11
Sep 2002

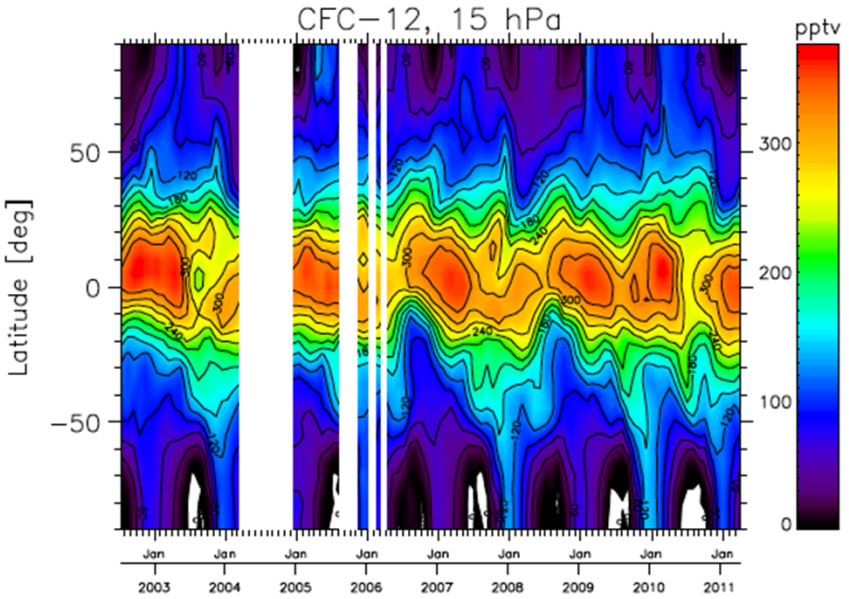
CFC-12
Sep 2002

Note the different altitude coverage!

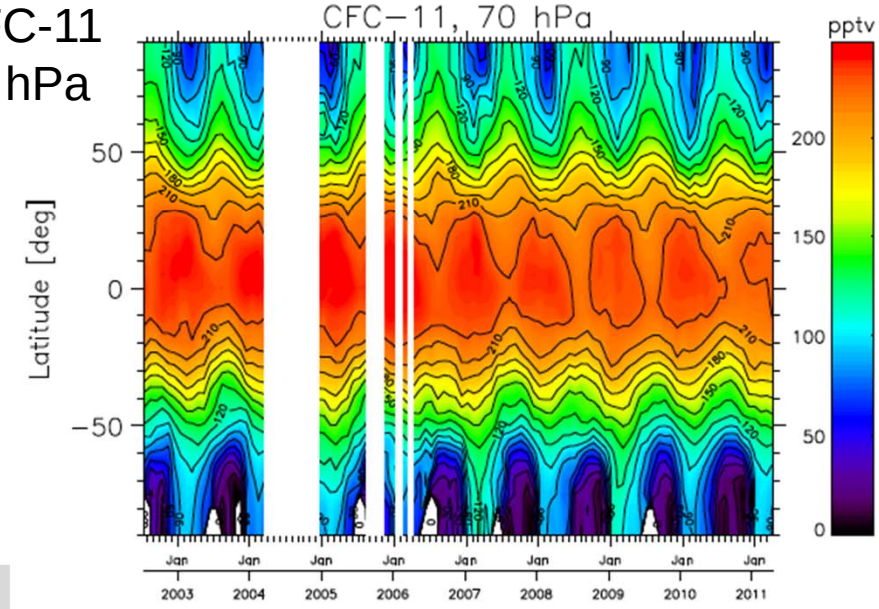
Global distributions derived from MIPAS – temporal evolution

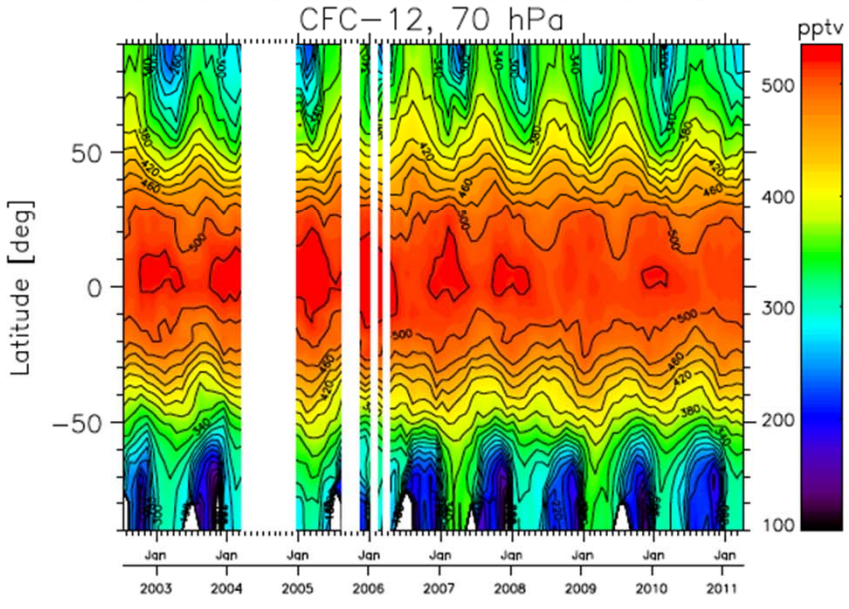
CFC-11
15 hPa



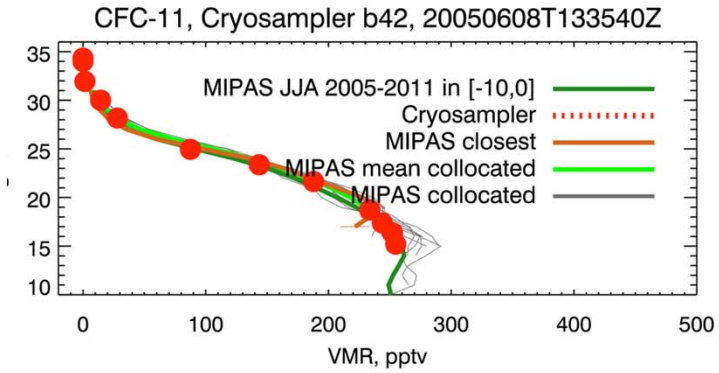


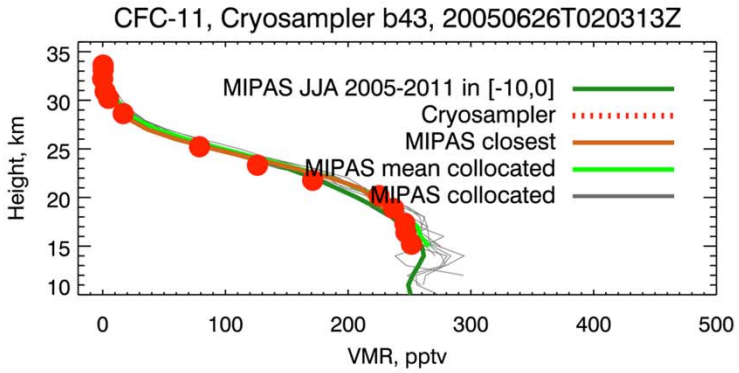
CFC-11
70 hPa

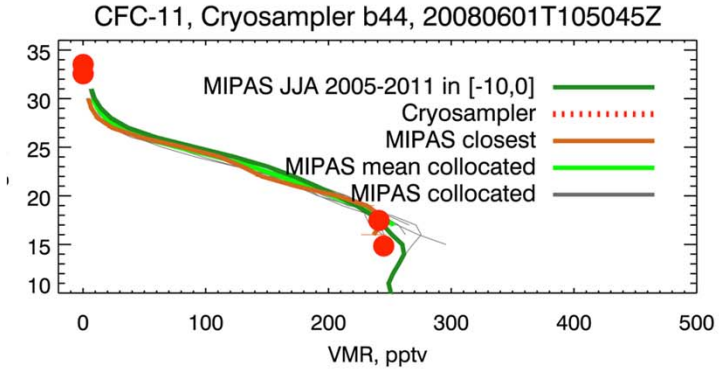


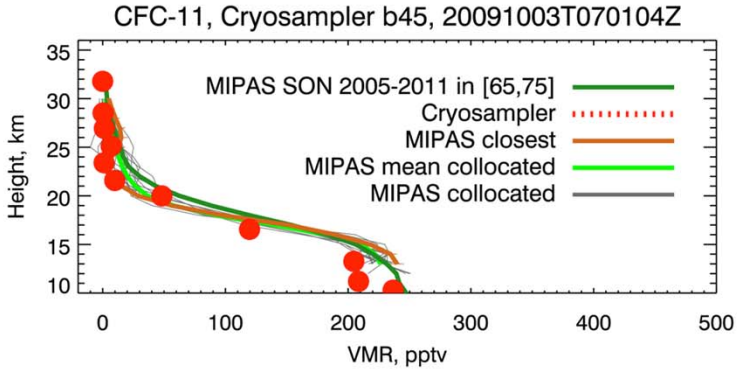


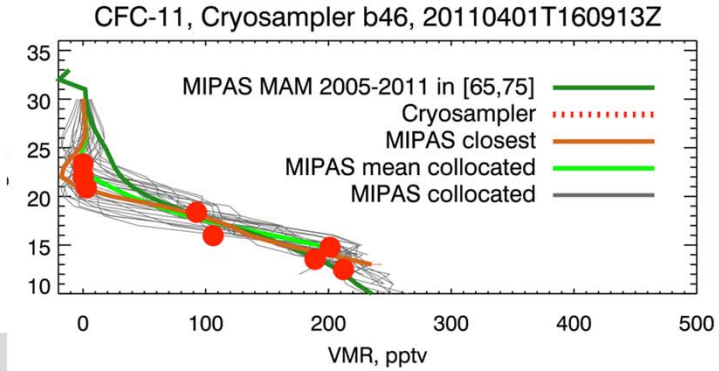
Validation – comparison to balloon-borne cryo-sampler data – CFC-11





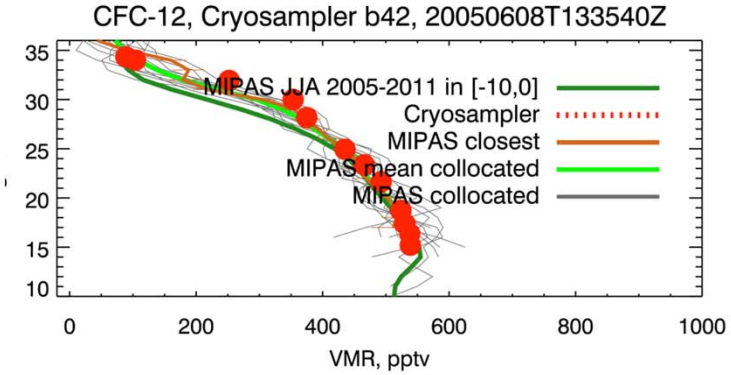


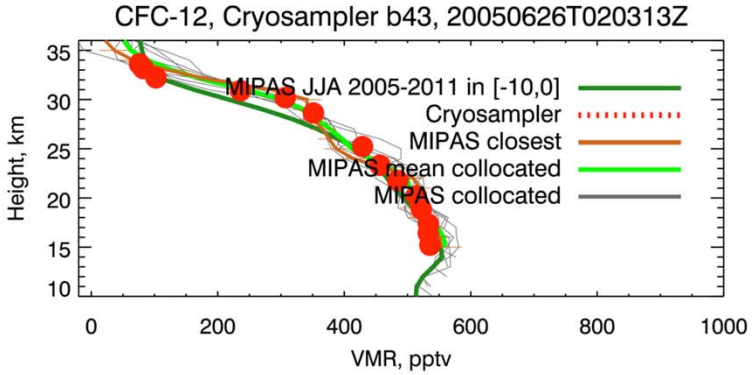


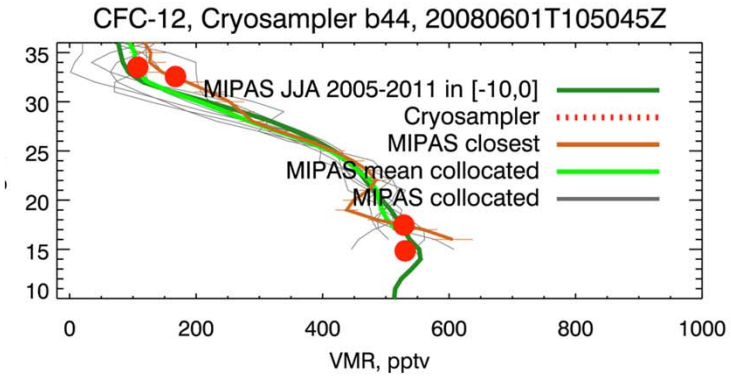


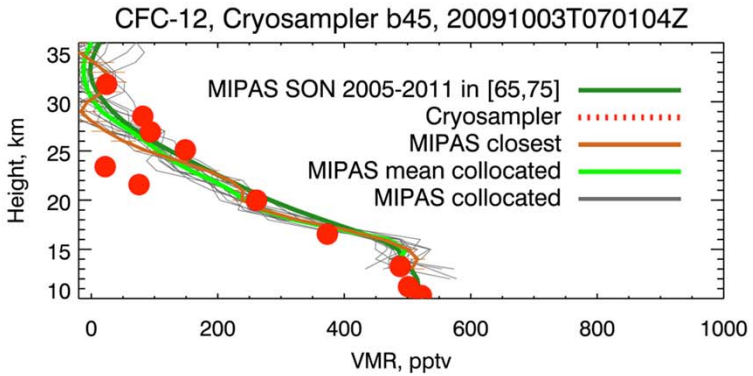
Balloon-data courtesy of Prof. Andreas Engel, Goethe-University Frankfurt

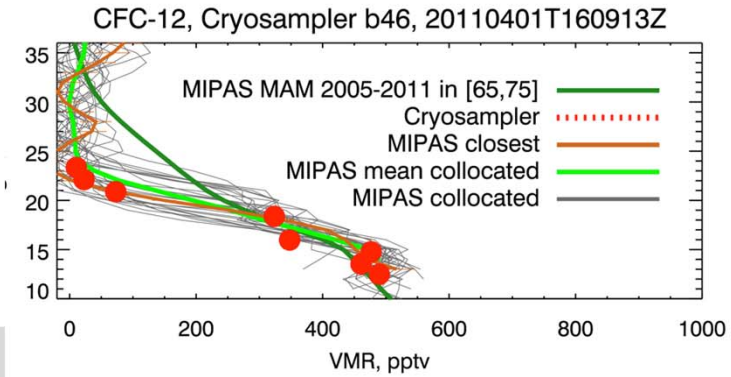
Validation – comparison to balloon-borne cryo-sampler data – CFC-12







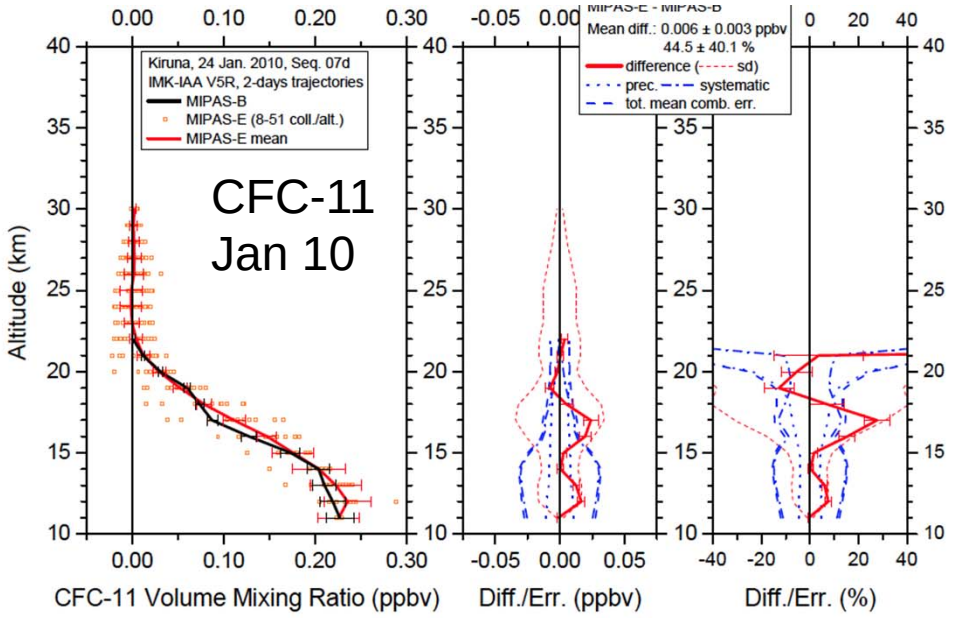


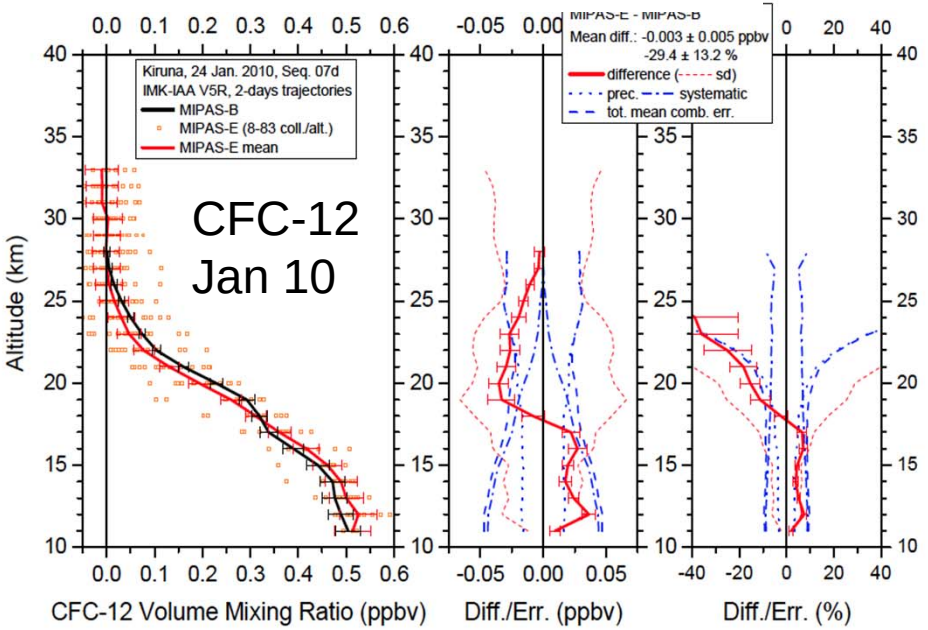


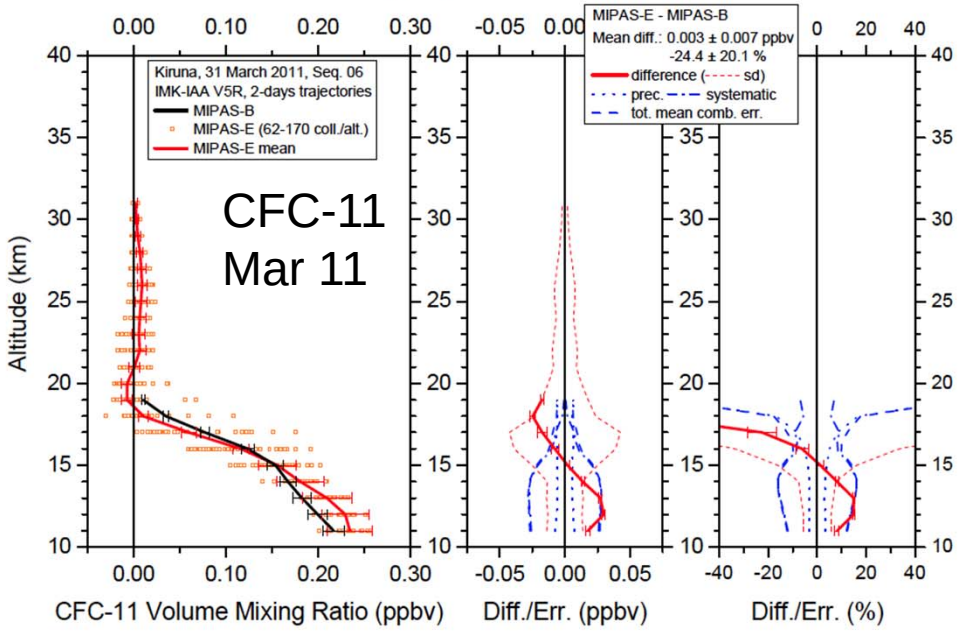
Balloon-data courtesy of Prof. Andreas Engel, Goethe-University Frankfurt

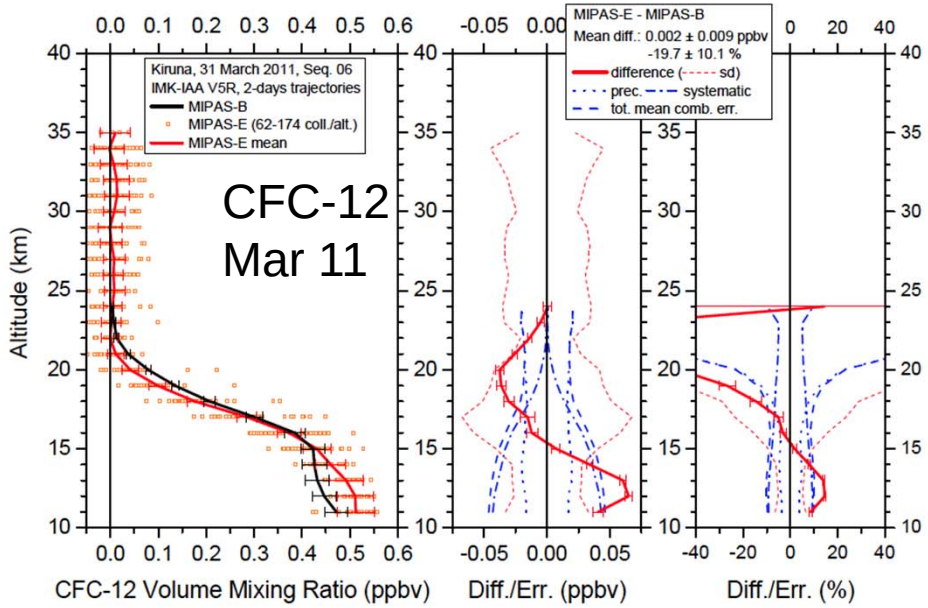
Validation – comparison to MIPAS-B

Balloon data and comparison by G. Wetzel, KIT, IMK-ASF



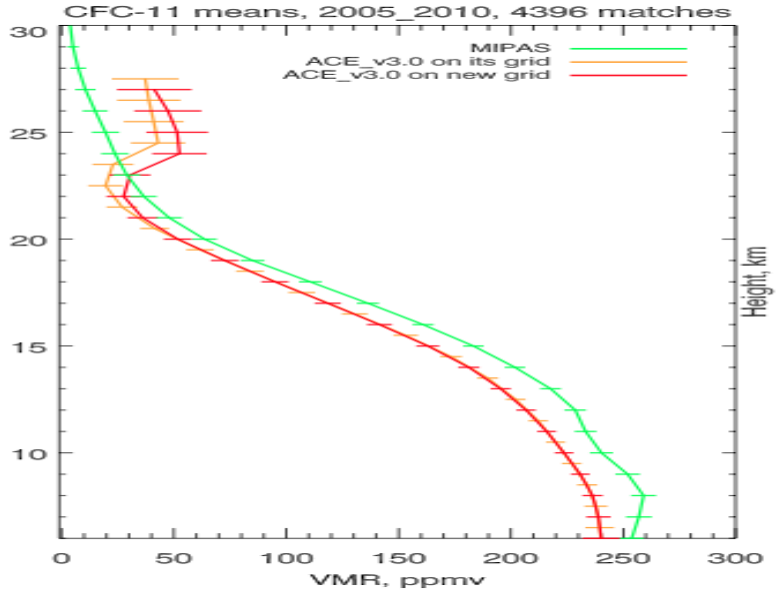


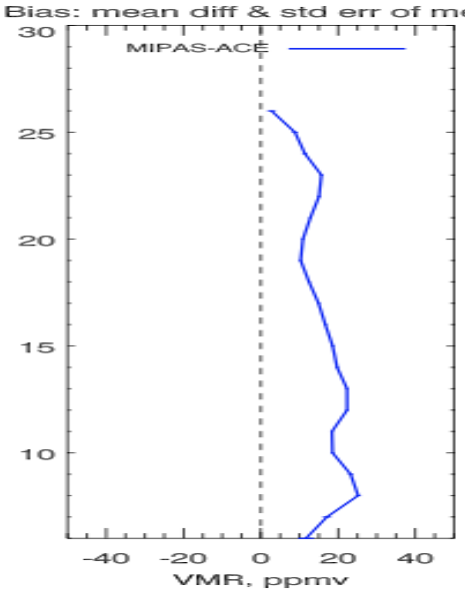


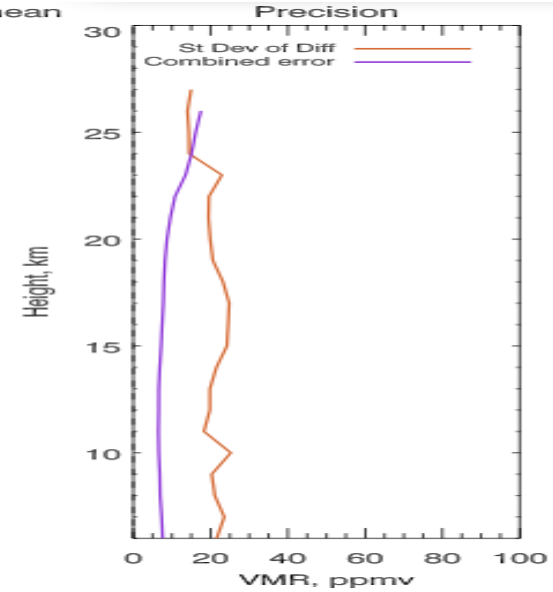


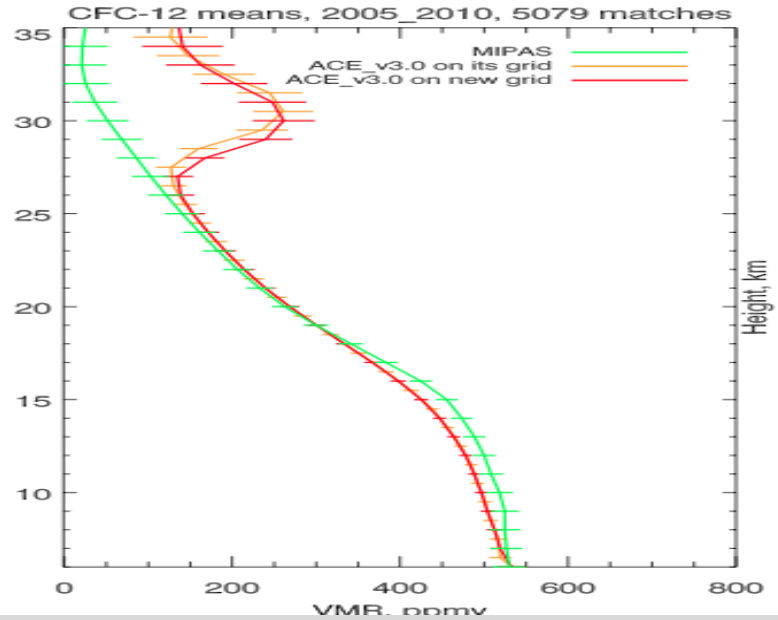
Validation – comparison to ACE-FTS

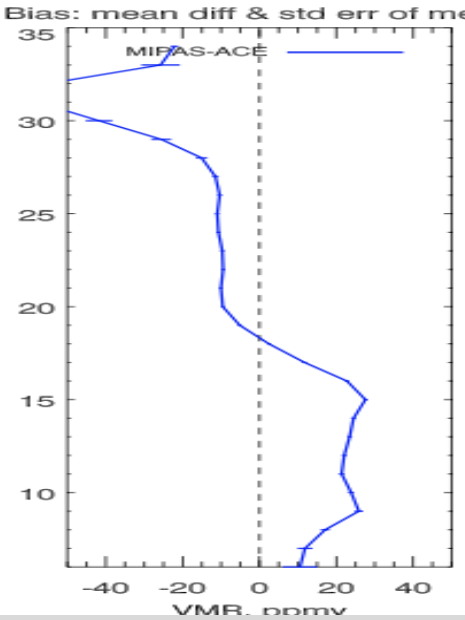
ACE-FTS data courtesy of K. Walker, UofT

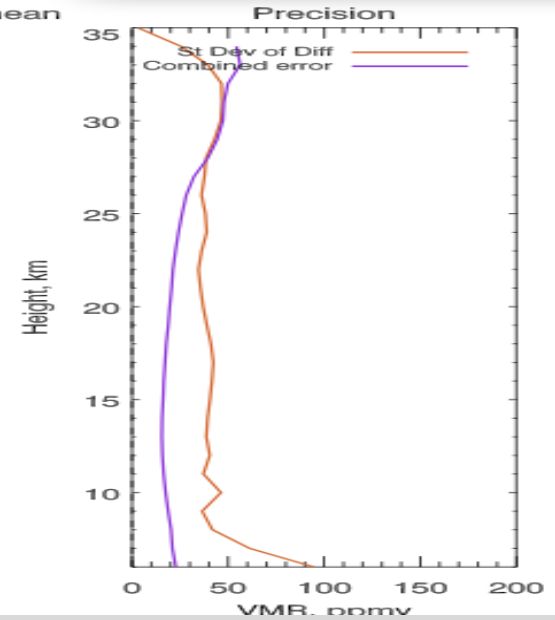






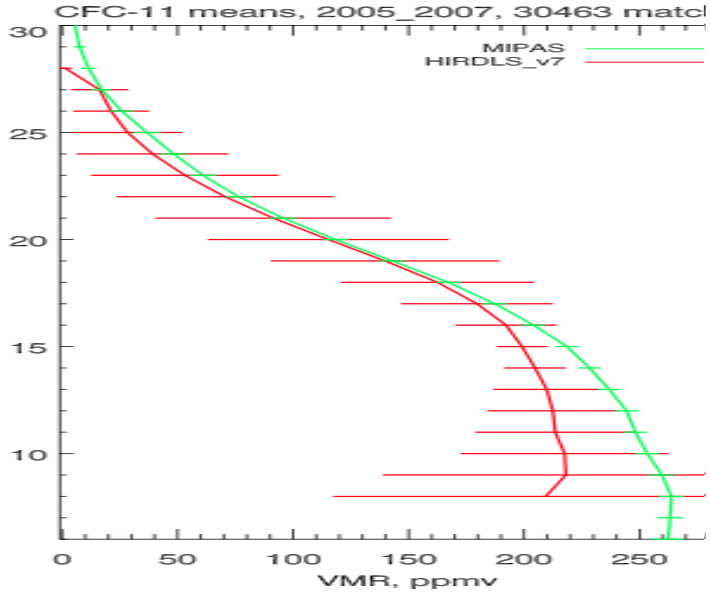


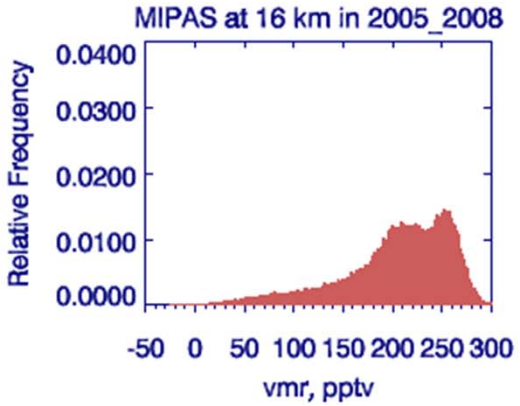


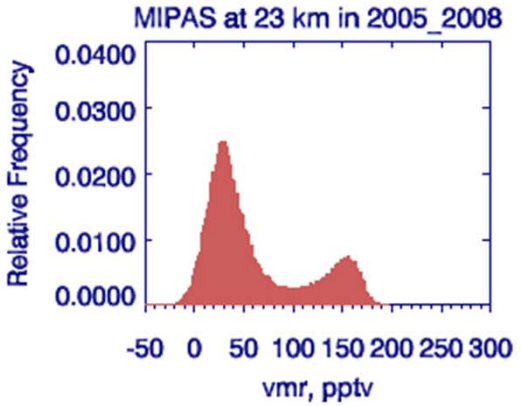


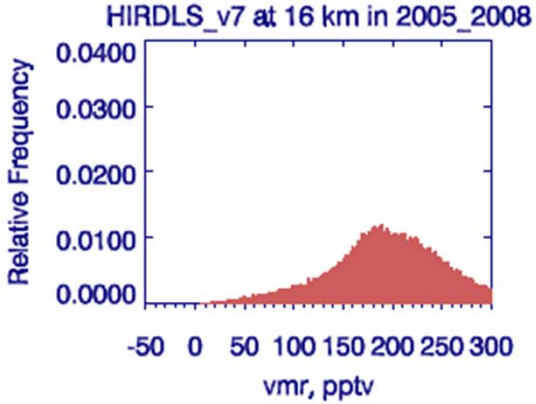
Validation – comparison to HIRDLS

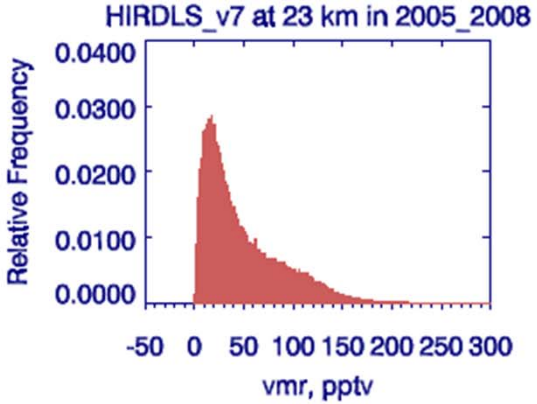
HIRDLS data courtesy of J. Gille, NCAR, Boulder

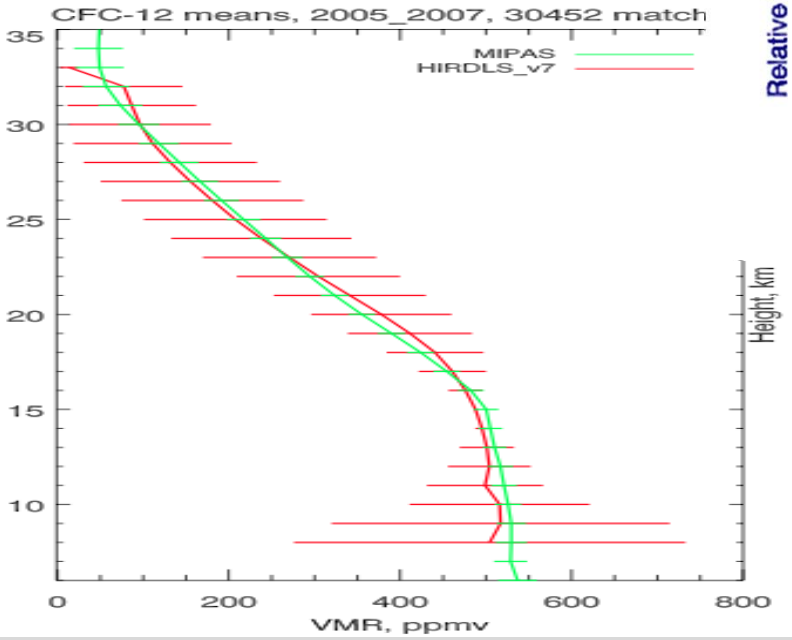


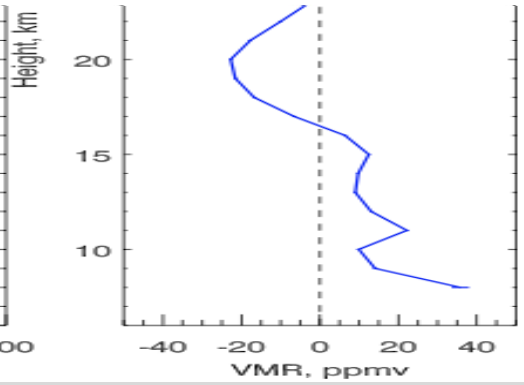


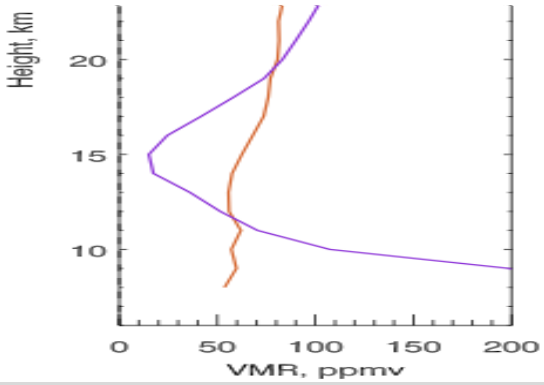












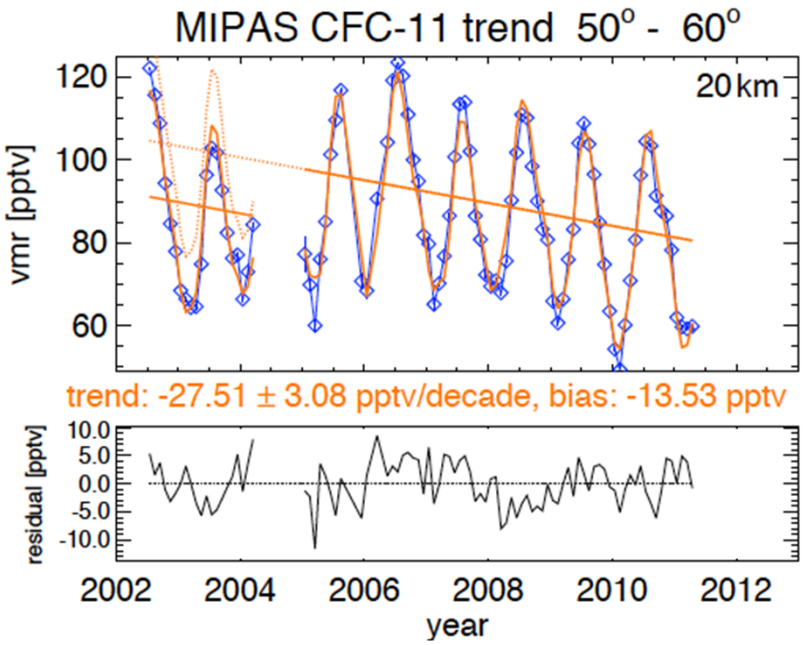
Trend assessment - Method

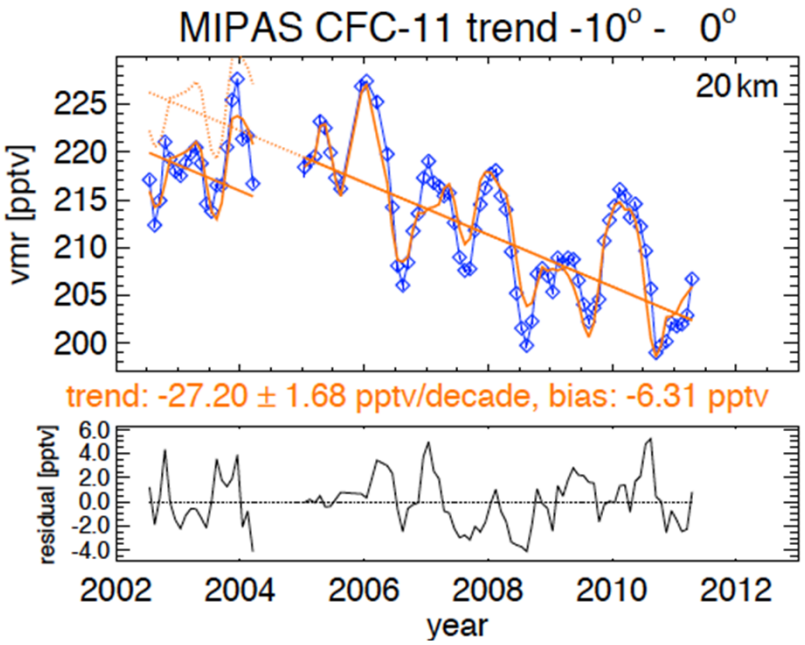
Multivariate Linear Regression:

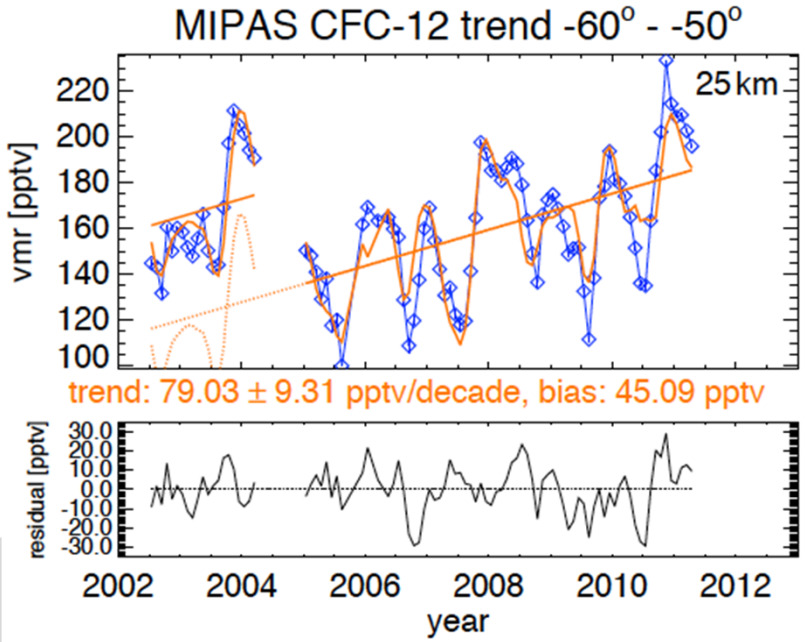
$$\mathrm{VMR}(t) = a + bt + c_1 \mathrm{qbo}_1(t) + d_1 \mathrm{qbo}_2(t) + \\ + \sum_{n=2}^{9} \left(c_n \sin \frac{2\pi t}{l_n} + d_n \cos \frac{2\pi t}{l_n} \right)$$

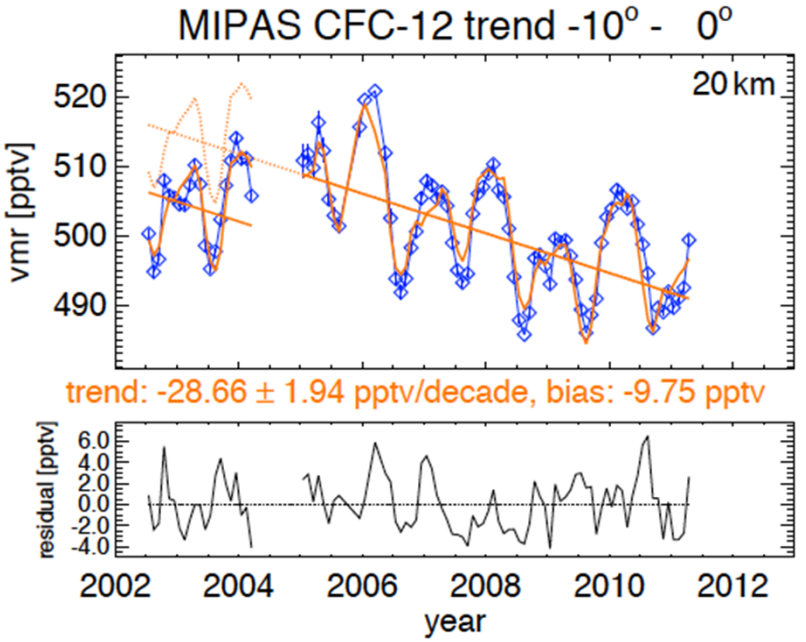
a = constant term
b = linear term (“trend”)
c_1, d_1 = coefficients for the QBO proxies qbo_1 and qbo_2 (= normalized Singapore winds at 30 and 50 hPa)
c_n, d_n = coefficients for sinusoidal oscillations with periods of 1 year, 6 months, and higher harmonics (to model the more saw-tooth like variations)
A potential bias between first and second MIPAS observation period is accounted for by adding its uncertainty block-wise to the covariance matrix of the fit. Model errors and autocorrelations are considered, too (see von Clarmann et al., ACP, 2010; Stiller et al., ACP, 2012).

Examples of time series and fits

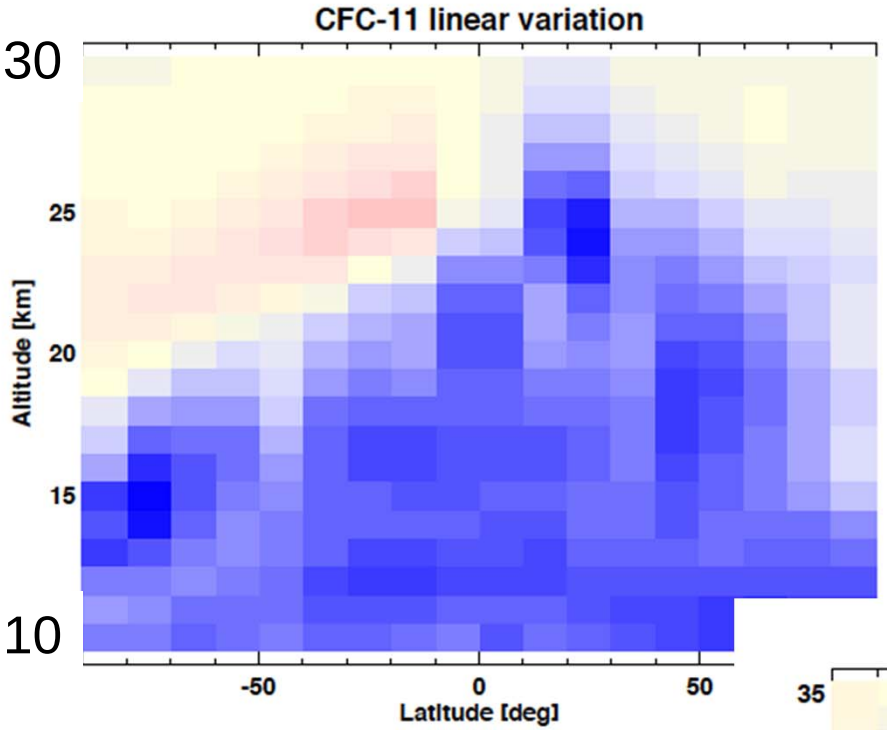


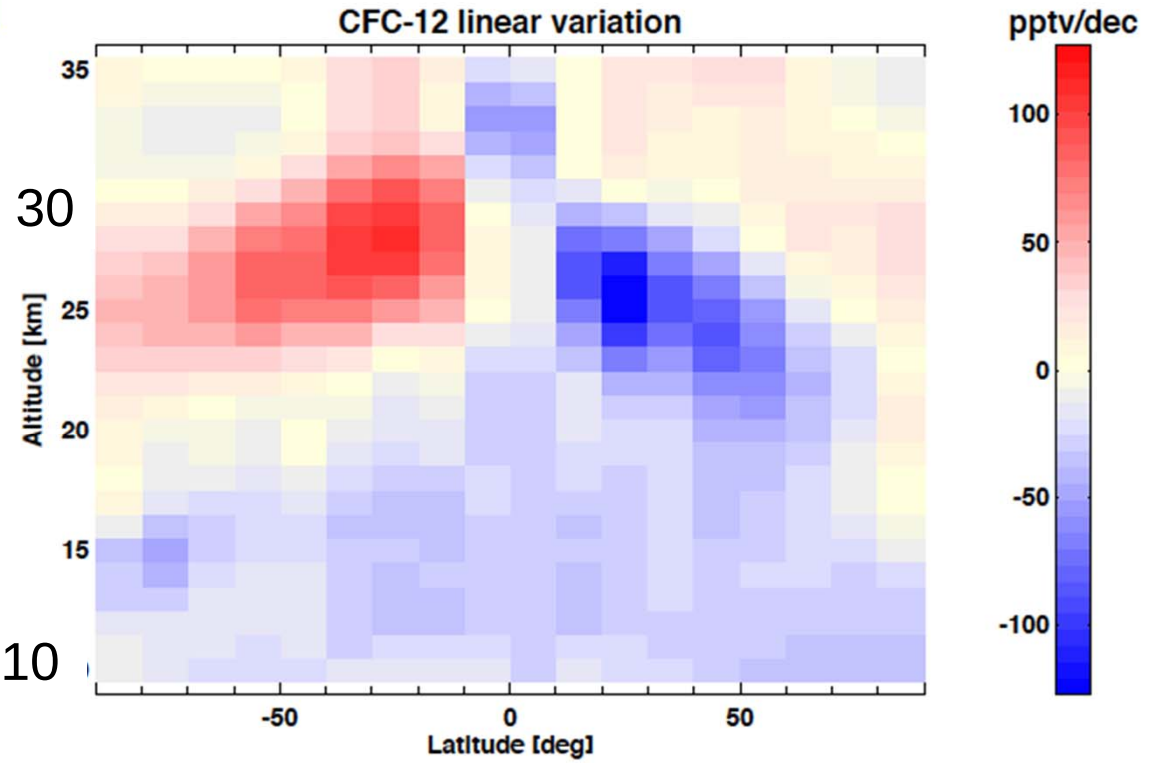




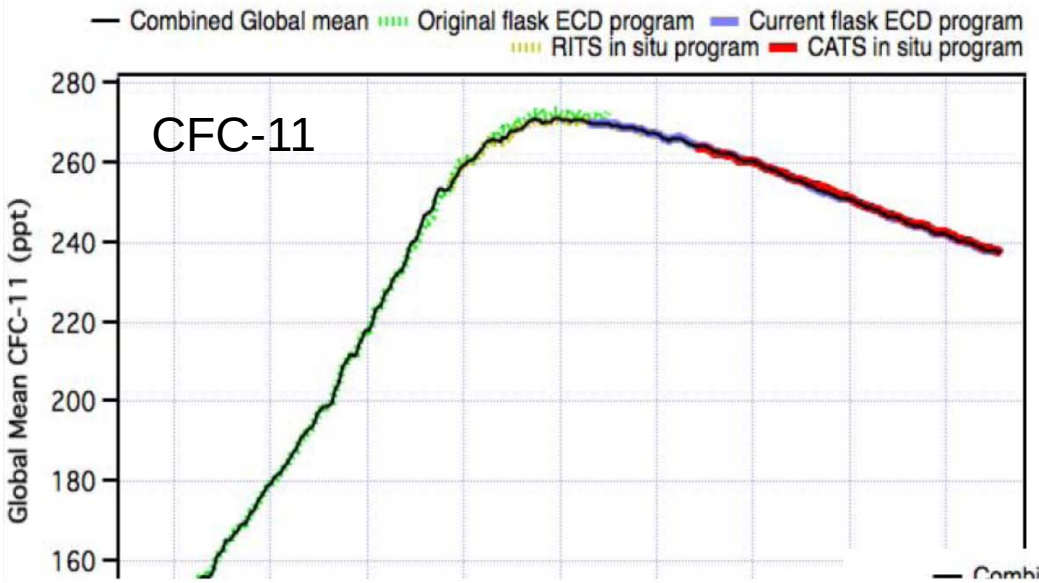


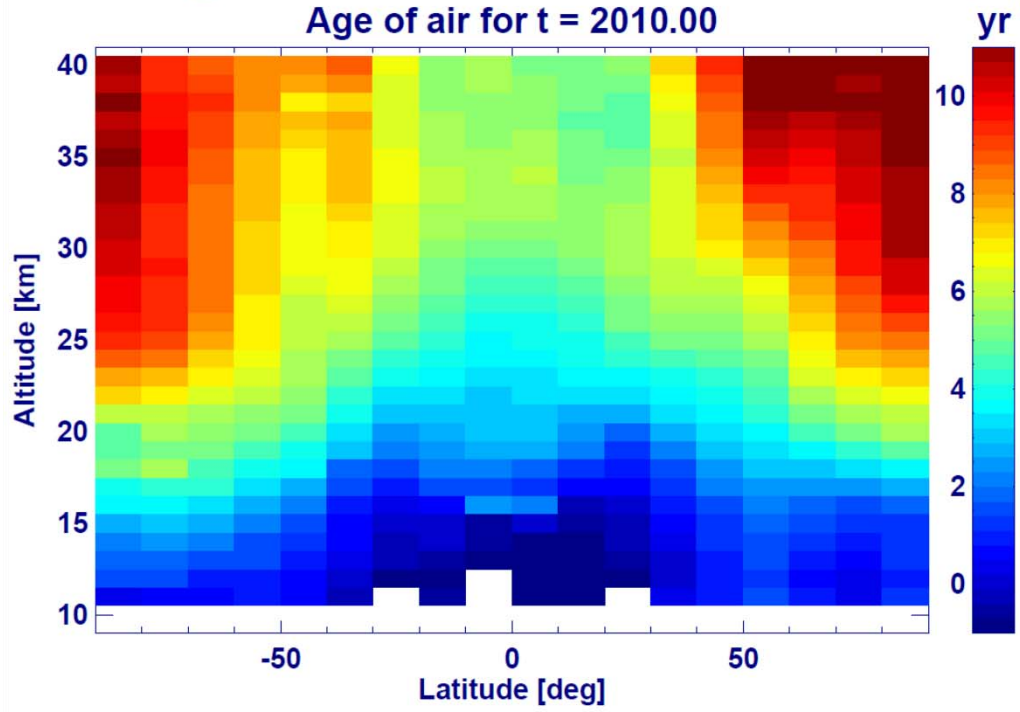
Derived trends

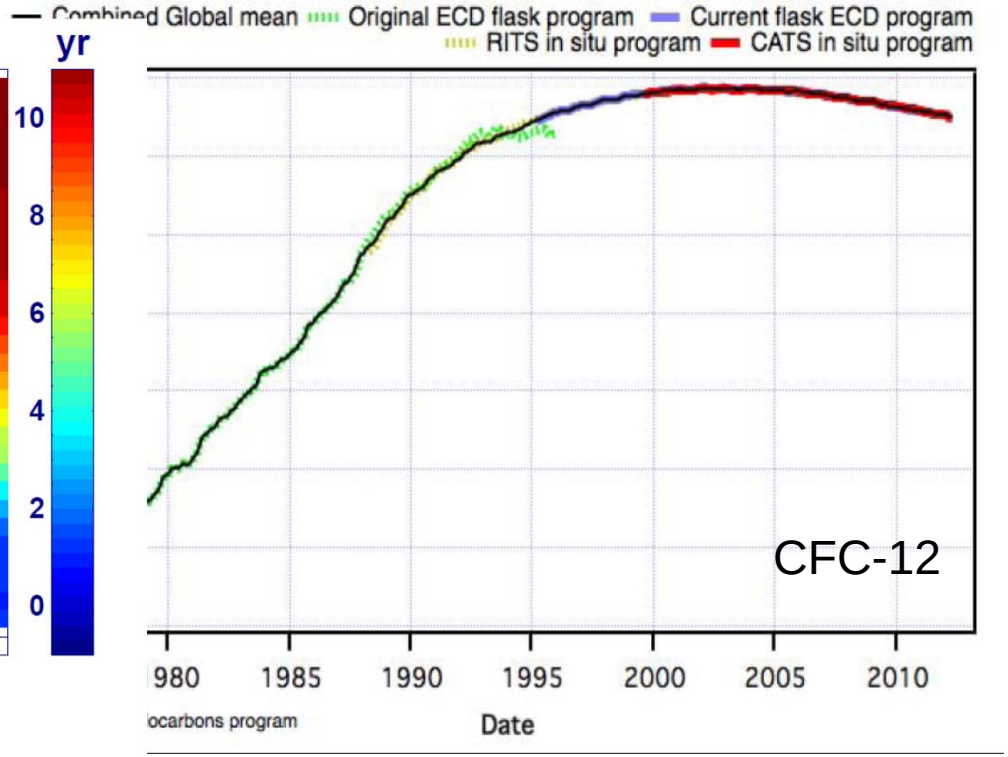




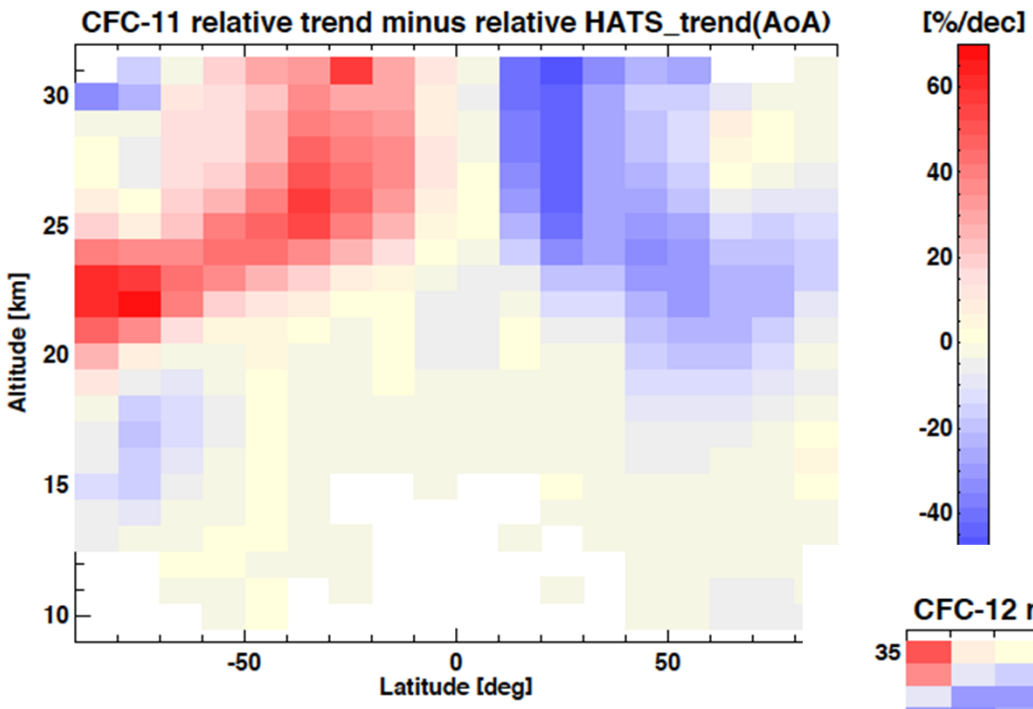
What trends do we expect?





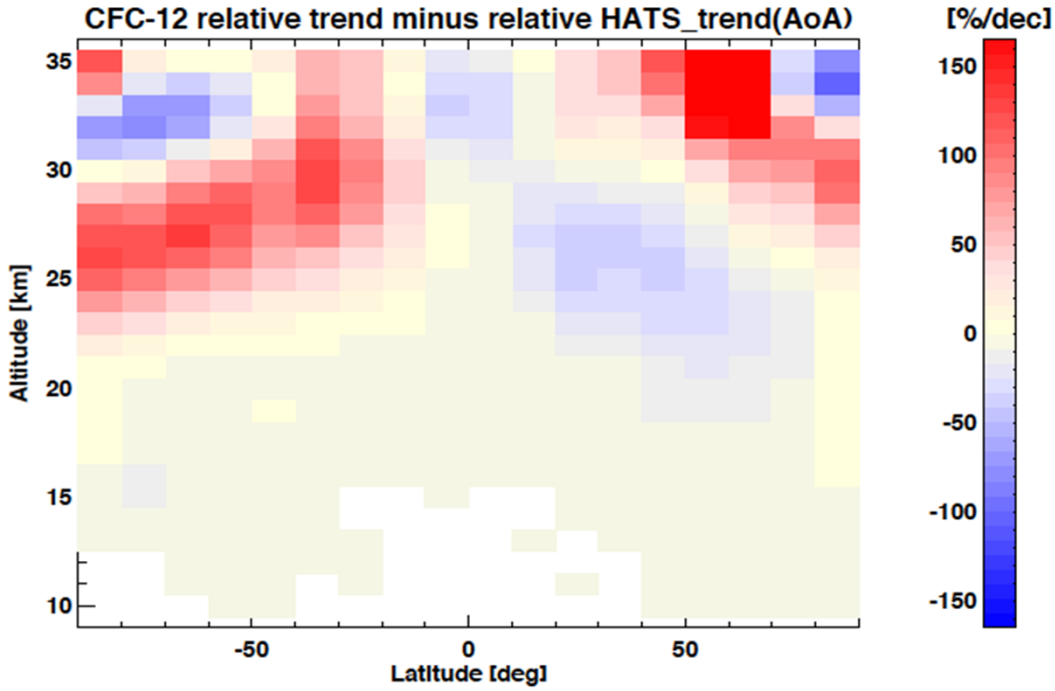


Unexplained trends



MIPAS-observed trends were corrected for trends observed <age> years before at the surface

➔ Unexplained trends



Candidate explanations:

- The long old tail of the age spectrum
- Changes of transport and mixing patterns

Summary/Conclusions

- A ten-years data record of CFC-11 and CFC-12 is available from MIPAS.
- The data show no significant biases in comparison to balloon-borne instruments; CFC-11 is higher than ACE-FTS and HIRDLS in the UTLS.
- The global distributions reveal the patterns expected for the Brewer-Dobson circulation and QBO.
- Clear seasonal cycles are present, more prominent at higher latitudes.
- The time series have been fitted by a multi-variate linear regression approach.
- Linear “trends” are always negative in the UTLS.
- Above 20 km, significant positive trends are also observed.
- They cannot be explained by surface trends corrected for the age of stratospheric air.
- Simplifications in the correction approach – like ignoring the age of air spectrum – cannot explain both signs: positive **and** negative unexplained trends.
- ➔ The unexplained trends provide evidence of changes in transport or mixing patterns, i.e. changing Brewer-Dobson circulation.

Kellmann et al., 2012; SPARC-DI report, in prep.; Stiller et al., 2012; von Clarmann et al., 2010; Eckert et al., in prep.